DOE/GO-102001-1165
NREL/BK-710-29267
May 2001

5.2.4 Absorption Cooling

On the surface, the idea of using an open flame or steam to generate cooling might appear contradictory, but the idea is actually very elegant. And it has been around for quite a while—the first patent for absorption cooling was issued in 1859 and the first system built in 1860. Absorption cooling is more common today than most people realize. Large, high-efficiency, double-effect absorption chillers using water as the refrigerant dominate the Japanese commercial air-conditioning market. While less common in the U.S., interest in absorption cooling is growing, largely as a result of deregulation in the electric power industry. The technology is even finding widespread use in hotels that use small built-in absorption refrigerators (because of their virtually silent operation) and for refrigerators in recreational vehicles (because they do not require electricity).

Opportunities

Absorption cooling is most frequently used to air-condition large commercial buildings. Because there are no simplifying rules of thumb to help determine when absorption chillers should be used, a life-cycle cost analysis should be performed on a case-by-case basis to determine whether this is an appropriate technology. Absorption chillers may make sense in the following situations: where there are high electric demand charges, where electricity use rates are high, where summertime natural gas prices are favorable, or where utility and manufacturer rebates exist. Absorption chillers can be teamed with electric chillers in "hybrid" central plants to provide cooling at the lowest energy costs—in this case, the absorption chillers are used during the summer to avoid high electric demand charges, and the electric chillers are used during the winter when they are more economical. Because absorption chillers can make use of waste heat, they can essentially provide free cooling in certain facilities.

Absorption cooling systems can most easily be incorporated into new construction, though they can also be used as replacements for conventional electric chillers. A good time to consider absorption cooling is when an old electric chiller is due for replacement.

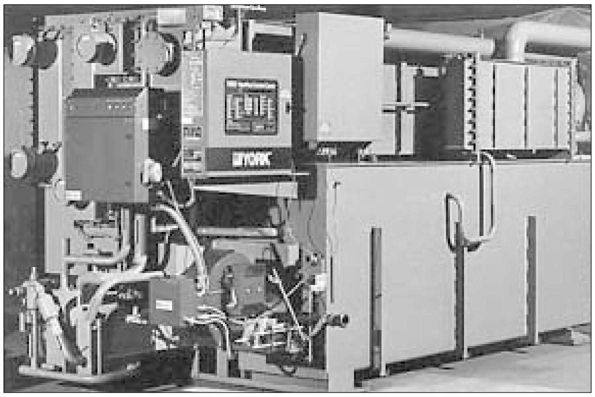
Technical Information

An absorption cooling cycle is similar to a vapor-compression cycle in that it relies on the same three basic principles (1) when a liquid is heated it boils (vaporizes), and when a gas is cooled it condenses; (2) lowering the pressure above a liquid reduces its boiling point; and (3) heat flows from warmer to cooler surfaces. Instead of mechanically compressing a gas (as occurs with a vapor-compression refrigeration cycle), absorption cooling relies on a thermochemical "compressor." Two different fluids are used, a refrigerant and an absorbent, that have high "affinity" for each other (one dissolves easily in the other). The refrigerant (usually water) can change phase easily between liquid and vapor and circulates through the system. Heat from natural gas combustion or a waste-heat source drives the process. The high affinity of the refrigerant for the absorbent (usually lithium bromide or ammonia) causes the refrigerant to boil at a lower temperature and pressure than it normally would and transfers heat from one place to another.

Absorption chillers can be direct-fired or indirect-fired, and they can be single-effect or double-effect (explanation of these differences is beyond the scope of this discussion). Double-effect absorption cycles capture some internal heat to provide part of the energy required in the generator or "desorber" to create the high-pressure refrigerant vapor. Using the heat of absorption reduces the steam or natural gas requirements and boosts system efficiency.

Absorption cooling equipment on the market ranges in capacity from less than 10 tons to over 1,500 tons (35 to 5,300 kW). Coefficients of performance (COPs) range from about 0.7 to 1.2, and electricity use ranges from 0.004 to 0.04 kW/ton of cooling. Though an electric pump is usually used (the principal exceptions being the small hotel and recreational vehicle [RV] refrigerators), pump energy requirements are relatively small because pumping a liquid to the high-side pressure requires much less electricity than does compressing a gas to the same pressure.

High-efficiency, double-effect absorption chillers are more expensive than electric-driven chillers. They require larger heat exchangers because of higher heat-rejection loads; this translates directly into higher



Source: American Gas Cooling Center

This York® Millennium™ Direct-Fired Double-Effect Absorption Chiller/Heater replaces an electric chiller and boiler, reducing the floor-space requirement by up to 40%.

costs. Non-energy operating and maintenance costs for electric and absorption chillers are comparable. Significant developments in controls and operating practice have led the current generation of double-effect absorption chillers to be praised by end-users for their low maintenance requirements.

The potential of absorption cooling systems to use waste heat can greatly improve their economics. Indirect-fired chillers use steam or hot water as their primary energy source, and they lend themselves to integration with on-site power generation or heat recovery from incinerators, industrial furnaces, or manufacturing equipment. Indirect-fired, double-effect absorption chillers require steam at around 370°F and 115 psig (190°C and 900 kPa), while the less efficient (but also less expensive) single-effect chillers require hot water or steam at only 167–270°F (75–132°C). Triple-effect chillers are also available.

References

Cler, Gerald, et al., *Commercial Space Cooling and Air Handling Technology Atlas*, E Source, Inc., Boulder, CO, 1997; (303) 440-8500; www.esource.com.

ASHRAE Handbook: 1997 Fundamentals, pp. 1-20, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Atlanta, GA; www.ashrae.org.

Wood, Bernard D., *Application of Thermodynamics*, Addison-Wesley Publishing Company, Reading, MA, 1982, pp. 238-257.

Contacts

Distributed Energy Resources Program, Office of Power Technologies, EERE, U.S. Department of Energy, 1000 Independence Avenue, SW, Washington, DC 20585.

Building Equipment Research Program, Energy Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831; (865) 574-2694.

American Gas Cooling Center, 400 N. Capitol Street, NW, Washington, DC 20001; (202) 824-7141, www.agcc.org.

TYPICAL INSTALLED COSTS OF VARIOUS TYPES OF CHILLERS ($/TON)

CHILLER TYPE	SMALL (<500 tons)	MEDIUM (500–1,000 tons)	LARGE (1,000–1,500 tons)
Electrically Driven	$300	$280	<$280
Single-Effect Absorption	$285	$210	$195
Double-Effect Absorption	$600	$525–$550	$460

Source: Supersymmetry USA